10:32:56 OCA PAD AMENDMENT - PROJECT HEADER INFORMATION 02/03/95

Active

Project #: G-35-620 Cost share #: G-35-329 Rev #: 7
Center # : 10/24-6-R7361-0A0 Center shr #: 10/22-1-F7361-0A0 OCA file #:
Work type : RES
Contract#: ATM-9113681 Mod #: ADM REVISION Document : GRANT
Prime #: Contract entity: GTRC

Subprojects ? : Y CFDA: 47.050
Main project #: PE #: N/A

Project unit: E & A SCI Unit code: 02.010.140
Project director(s):
WINE P H EOEML (404)894-3424

Sponsor/division names: NATL SCIENCE FOUNDATION / GENERAL
Sponsor/division codes: 107 / 000

Award period: 911015 to 960331 (performance) 960630 (reports)

Sponsor amount	New this change	Total to date
Contract value	0.00	281,700.00
Funded	0.00	281,700.00
Cost sharing amount		3,493.00

Does subcontracting plan apply ?: N

Title: COMPARATIVE STUDY OF ATMOSPHERIC SULFUR BUDGET IN DIFFERENT NATURAL ENVIRONME

PROJECT ADMINISTRATION DATA

OCA contact: Jacquelyn L. Bendall 894-4820

Sponsor technical contact

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(703)306-1522

NATIONAL SCIENCE FOUNDATION
4201 WILSON BOULEVARD
ARLINGTON, VA 22230

Sponsor issuing office

LEE A. DEHERRERA
(703)306-1212

NATIONAL SCIENCE FOUNDATION
4201 WILSON BOULEVARD
ARLINGTON, VA 22230

Security class (U,C,S,TS) : U ONR resident rep. is ACO (Y/N): N
Defense priority rating : N/A NSF supplemental sheet
Equipment title vests with: Sponsor GIT X

Administrative comments -
ISSUED TO CHANGE TO UNIT CODE FROM EOEML TO E&A SCIENCES.

GEORGIA INSTITUTE OF TECHNOLOGY
OFFICE OF CONTRACT ADMINISTRATION

NOTICE OF PROJECT CLOSEOUT

Closeout Notice Date 04/18/96

Project No. G-35-620 Center No. 10/24-6-R7361-0A0

Project Director WINE P H School/Lab E & A SCI

Sponsor NATL SCIENCE FOUNDATION/GENERAL

Contract/Grant No. ATM-9113681 Contract Entity GTRC

Prime Contract No.

Title COMPARATIVE STUDY OF ATMOSPHERIC SULFUR BUDGET IN DIFFERENT NATURAL ENVIR

Effective Completion Date 960331 (Performance) 960630 (Reports)

Closeout Actions Required:	Y/N	Date Submitted
Final Invoice or Copy of Final Invoice	N	
Final Report of Inventions and/or Subcontracts	N	
Government Property Inventory & Related Certificate	N	
Classified Material Certificate	N	
Release and Assignment	N	
Other	N	

Comments
LETTER OF CREDIT APPLIES. 98A SATISFIES PATENT REPORT.

Subproject Under Main Project No.

Continues Project No.

Distribution Required:

Project Director	Y
Administrative Network Representative	Y
GTRI Accounting/Grants and Contracts	Y
Procurement/Supply Services	Y
Research Property Managment	Y
Research Security Services	N
Reports Coordinator (OCA)	Y
GTRC	Y
Project File	Y
Other	N
	N

G 35-620

Georgia Tech

School of Earth and Atmospheric Sciences
Georgia Institute of Technology
Atlanta, Georgia 30332-0340
404•894•3893
404•853•0232 (FAX)

National Science Foundation
Division of Atmospheric Sciences
Washington, D.C. 20550
Attn.: Dr. Jarvis Moyers

Atlanta, July 13, 1992

Dear Jarvis:

Enclosed please find my annual progress report for year 01 of NSF project ATM-9113681, entitled: "A Comparative Study of the Atmospheric Sulfur Budget in Different Natural Environments".

Yours truly,

Harald Berresheim

Research Scientist

NSF Grant No. ATM-9113681, Atmospheric Chemistry Division

A COMPARATIVE STUDY OF THE ATMOSPHERIC SULFUR BUDGET IN DIFFERENT NATURAL ENVIRONMENTS

Progress Report for Year 01 (10/15/91 - 10/14/92)

PI: Dr. Harald Berresheim
Georgia Institute of Technology, School of Earth and Atmospheric Sciences, Atlanta, GA 30332, Phone: (404) 894-3824

In the first year of this renewal project we have continued our previous collaborations with other research groups at Georgia Tech, namely those led by Dr. Fred Eisele (GTRI) and Prof. W. Chameides (EAS), focussing on the potentially important role of marine dimethylsulfide (DMS) emissions to global climate change (DMS-cloud-climate-hypothesis). Our collaboration with Dr. Eisele's group during the previous grant period resulted in the development of a new mass spectrometer sampling and interface device making it possible to measure DMS, SO_2, and dimethylsulfoxide (DMSO) at sub-parts-per-trillion (sub-pptv) levels on a real-time basis. Together with the other measurement capabilities of Dr. Eisele's group we are now able to measure almost all of the important reactant and product species involved in atmospheric DMS oxidation under real field conditions. The (continued) development of these techniques represents an essential step in approaching one of our major goals in this project: to directly trace DMS photooxidation reactions in the marine atmosphere and determine the relative importance of the different oxidation pathways involved. Knowledge of the relative yields of the major end oxidation products (dimethylsulfone (DMSO2), methanesulfonic acid (MSA), sulfuric acid) under real field conditions is an essential prerequisite for verifying the above mentioned hypothesis. To this date, techniques based on selected ion chemical ionization mass spectrometry (SI/CI/MS) and gas chromatography (GC) interfacing have been established and successfully tested for almost all of the sulfur compounds mentioned above. The only exception thus far is DMSO2 which is very elusive to most mainstream analytical techniques due to its unique physical and chemical properties. In the fall of 1991 we began to focus on filling this last major analytical gap by conducting a series of laboratory experiments involving our combined GC/SI/CI/MS system and an in-line high temperature gold catalyst reactor in which DMSO2 exiting from the GC column was pyrolyzed to SO_2. The resulting SO_2 was then detected by SI/CI/MS. These preliminary experiments showed very promising results. SO_2 yields near 100% were observed for temperatures between 700-800°C and a linear signal response was measured for DMSO2 concentrations down to the mid-pptv range. We are currently preparing a gas phase calibration source providing gaseous DMSO2 standards accurately down to low pptv levels. The analytical studies will be continued using this system as well as new modified gold reactors in further laboratory experiments to be conducted in the next project year (fall 1992). We are confident that by then we can establish the DMSO2 catalytic technique to maturity and field test it, probably in spring of 1993, at Sapelo Island, Georgia.

Our collaboration with Prof. Chameides' modelling group has resulted in a joint paper currently under review for publication in J. Geophys. Res. (see references below). This paper is focussed on yet another aspect of the DMS-cloud-climate hypothesis, namely the potential of sulfuric acid particles formed from DMS oxidation to grow to cloud condensation nuclei (CCN). This process links DMS photooxidation to cloud microphysics and is crucial to the validity of the above hypothesis. Our calculations in this paper suggest that this linkage may exist under real field conditions, but that it may only be of importance

over very remote oceanic regions where the number of pre-existing CCN particles is low (less than about 10 cm^{-3}).

Another major objective of the present project is the role of both soils and vegetation in the global atmospheric cycles of carbonyl sulfide (COS) and carbon disulfide (CS_2). A major field experiment focussing on this objective has been conducted in the first year of this project between April-July, 1992. We have measured the fluxes of both COS and CS_2 over a corn field in southwestern Georgia using the gradient flux technique. The measurements were performed during three major growth stages of the corn: (a) shortly after seeding (bare soil), (b) at mid-growth stage (corn about 70 cm high), and (c) shortly before harvest (corn height: 320 cm). A total of forty vertical concentration profiles for each COS and CS_2 were measured including an average of 4 - 5 profiles per day for each compound. For these measurements we joined the Microclimate Research group of the USDA Southern Piedmont Conservation Research Center in Watkinsville, Georgia, led by Drs. L. Harper and R. Sharpe, who continuously measured CO_2, water vapor, and heat flux at this site employing eddy correlation techniques. Other measurements by this group involved gradient flux measurements of ammonia and nitrous oxide, and extensive plant and soil analysis studies. We have just begun to evaluate our COS and CS_2 profile data obtained in this experiment. The analysis of the data will probably take several months (i.e., into the next project year). Flux calculations will be based on the micrometeorological data obtained by the USDA group. A detailed analysis will then be performed with respect to diel and seasonal (growth-stage dependent) variations of the COS/CS_2 biosphere-atmosphere exchange rates. Furthermore, the correlation between CO_2 and COS/CS_2 fluxes will be evaluated.

The following is a list of research papers (published or currently submitted for publication) which have resulted from NSF support in the first year of the present project:

Berresheim, H., and V.D. Vulcan, Vertical Distributions of COS, CS_2, and Other Sulfur Compounds in a Loblolly Pine Forest, Atmos. Environ., 26A, 2031-2036 (1992).

Berresheim, H., D.J. Tanner, and F.L. Eisele, Real-Time Measurement of Dimethylsulfoxide in Air, Anal. Chem., submitted (1992).

Berresheim, H., Distribution of Atmospheric Sulfur Species Over Various Wetland Regions in the Southeastern United States, Atmos. Environ., submitted (1992).

Lin, X., W.L. Chameides, H. Berresheim, C.S. Kiang, and A.W. Stelson, A Model Study of the Formation of Cloud Condensation Nuclei in Remote Marine Areas, J. Geophys. Res., submitted (1991).

G35-620
2

NSF Grant No. ATM-9113681, Atmospheric Chemistry Division

A COMPARATIVE STUDY OF THE ATMOSPHERIC SULFUR BUDGET IN DIFFERENT NATURAL ENVIRONMENTS

Progress Report for Year 02 (10/15/92 - 10/14/93)

PI: Dr. Harald Berresheim
Georgia Institute of Technology, School of Earth and Atmospheric Sciences, Atlanta, GA 30332, Phone: (404) 894-3824

1. Atmospheric DMS Chemistry and CCN Formation

The evaluation of our 1991 measurements conducted at Cheeka Peak Research Station (northeastern U.S. Pacific coast) as part of the Pacific Stratus Investigation (PSI-3) project resulted in a significantly improved understanding of the DMS-cloud-climate connection. This field study combined for the first time simultaneous measurements of dimethylsulfide (DMS), dimethylsulfoxide (DMSO), methanesulfonic acid (MSA), and sulfuric acid (H_2SO_4) in the gas phase. The latter three compounds were measured in collaboration between our group and Dr. Fred Eisele (Georgia Tech/GTRI/EOPSL). Total particle and cloud condensation nuclei (CCN) concentrations as well as aerosol ions were measured by a team from the University of Washington. The most important results of the Cheeka Peak experiment can be summarized as follows:

1. Based on the atmospheric mixing ratios and estimated lifetimes (1-3 hours) of DMSO, MSA, and H_2SO_4 we concluded that the dominant end product of DMS oxidation under the given conditions was most likely dimethylsulfone ($DMSO_2$), followed by H_2SO_4 and MSA.
2. All three oxidized species measured (DMSO, H_2SO_4, MSA) showed significant diel variations mostly in phase with each other.
3. A clear correlation was observed between the number of CCN measured at 0.3% supersaturation and both H_2SO_4 and aerosol non-sea-salt sulfate levels in marine air. A significant correlation was also found between DMS and H_2SO_4 levels. These results indirectly support a relationship between DMS and CCN. However, no correlations were found with CCN at higher supersaturation levels (0.9%) indicating the (additional) importance of non-sulfur compounds in cloud formation under such conditions.

In collaboration with Prof. W. Chameides' group at Georgia Tech we further analyzed the possible link between DMS oxidation and CCN formation in a model study. The model results showed that DMS oxidation is unlikely to produce a significant number of new CCN <u>if</u> SO_2 is the dominant intermediate species in the DMS-H_2SO_4 pathway.

2. Method Development

In our further collaboration with Dr. Eisele's group we successfully established for the first time a new real-time technique for the detection of $DMSO_2$ in ambient air using selected ion chemical ionization mass spectrometry (SI/CI/MS). In this technique $DMSO_2$ is complexed with NH_4^+ ions to form a corresponding cluster ion at 112 amu. The corresponding detection limit is 1 pptv at 50 sec signal integration. The technique is similar to that used for detecting DMSO as $H^+ \cdot DMSO$ (79 amu). Thus we are now able to continuously measure both gases with one SI/CI/MS system by just alternating between the corresponding mass signals at 79 amu and 112 amu.

3. Sources and Sinks of Atmospheric OCS and CS_2

A major field experiment focussing on the biosphere-atmosphere exchange of carbonyl sulfide (OCS) and carbon disulfide (CS_2) was conducted between April-July, 1992. Vertical profiles of both OCS and CS_2 were measured over a corn field in southwestern Georgia during three different growth stages of the corn: a) shortly after seeding (bare soil), b) at mid-growth stage (corn about 70 cm high), and c) shortly before harvest (corn height: 320 cm). All profiles indicated significant emissions of both gases from the soil (ultisol), depending on temperature and soil moisture. However, profiles measured in and above the corn canopy frequently showed a net deposition of OCS to the corn which most strongly developed in the midday to late afternoon hours. However, on some occasions the profiles were relatively constant and no significant variations were observed.

For these measurements we joined the Microclimate Research group of the USDA Southern Piedmont Conservation Research Center in Watkinsville, Georgia, led by Drs. L. Harper and R. Sharpe, who continuously measured CO_2, water vapor, and heat flux at this site employing eddy correlation techniques. We expect to obtain these data very soon from the USDA group who is currently still in the process of calculating the individual fluxes. Based on these data we will calculate OCS and CS_2 fluxes from our gradient measurements and verify a possible correlation between CO_2 and OCS uptake by the plants.

In July 1993 our group also conducts measurements of OCS and CS_2 fluxes in the Solling forest in Germany in collaboration with Dr. H. Bingemer, University of Frankfurt, and Prof. G. Gravenhorst, University of Göttingen. Fully equipped facilities including a 40 m tower are available at the site and CO_2 flux as well as eddy correlation measurements of temperature, solar radiation, water vapor and heat flux will be made by a team from the University of Göttingen. Dr. Bingemer's preliminary measurements at this site in the fall of 1992 have shown a very strong uptake of OCS by the forest canopy. The present study is aimed to further study this OCS deposition flux during the present summer season.

4. Other Discoveries

In our previous measurements we have frequently observed a strong increase of OCS and CS_2 levels in natural environments with changes in wind direction suggesting a possible advection from anthropogenic sources. Also, in the Atlanta urban area we often measured high mixing ratios particularly of CS_2 (> 100 pptv). The literature shows that to this date only a few anthropogenic OCS and CS_2 sources have been specifically identified with the major source being the chemical industry. We have discovered a new and potentially important anthropogenic OCS and CS_2 source: tire wear, i.e., abrasion of particles from automobile (and aircraft?) tires on pavements and other surfaces. Vulcanized rubber contains disulfide polymer groups which are continuously broken up during abrasion resulting in the emission of CS_2 as the major sulfur gas formed from this process. The emission rate is also a function of temperature and ambient ozone levels. Our preliminary estimates suggest that these automotive emissions represent at least 7% of the currently estimated global atmospheric OCS emissions into the atmosphere. Therefore, we concluded from our study that automobiles are <u>not</u> a negligible source of atmospheric sulfur, at least with respect to CS_2 and OCS, as has been assumed in the past based on measurements of fuel gas emissions alone.

5. Future Plans

Although Dr. Eisele has transferred his equipment permanently to NCAR where he is now working we intend to further collaborate with his group in future

field experiments. In a joint effort we have built a third SI/CI/MS system which remains at Georgia Tech mainly for future use by my group. This system is the most compact built thus far and therefore relatively easy to transfer to the field. We plan to use the system in year 03 of the present NSF project for participating in a SO_2 field intercomparison organized by Prof. G. Luther at the University of Delaware. However, we are also presently adopting a new HPLC-based SO_2 detection technique developed by Saltzman and coworkers at the University of Miami which we plan to use as our standard SO_2 method in the future, pending the results of next year's intercomparison experiment. The main thrust of our activities using the SI/CI/MS apparatus will be focussed on measuring DMSO and $DMSO_2$ in the marine atmosphere and developing measurement techniques for other atmospheric trace gases. Our long-term goal is to participate in future national and international field programs, predominantly within IGAC/MAGE and AEROCE/NARE to complement measurements of other groups related to atmospheric DMS chemistry and CCN formation. A dialogue with the individual organizing committees has been initiated.

6. Publications Resulting from NSF Support in Year 02:

1. Berresheim, H., F.L. Eisele, D.J. Tanner, D.S. Covert, L. McInnes, and D.C. Ramsey-Bell, Atmospheric Sulfur Chemistry and Cloud Condensation Nuclei (CCN) Concentrations Over the Northeastern Pacific Coast, J. Geophys. Res., in press (1993).

2. Berresheim, H., F.L. Eisele, and D.J. Tanner, A method for real-time detection of dimethylsulfone in ambient air, Anal. Chem., submitted (1993).

3. Pos, W.H., and H. Berresheim, Automotive tire wear as a source for atmospheric OCS and CS_2, Geophys. Res. Lett., 20, 815-817 (1993).

4. Berresheim, H., Distribution of Atmospheric Sulfur Species Over Various Wetland Regions in the Southeastern United States, Atmos. Environ., 27, 211-221 (1993).

5. Trainer, M., D.D. Parrish, M.P. Buhr, R.B. Norton, F.C. Fehsenfeld, K.G. Anlauf, J.W. Bottenheim, Y.Z. Tang, H.A. Wiebe, J.M. Roberts, R.L. Tanner, L. Newman, V.C. Bowersox, J.F. Meagher, K.J. Olszyna, M.O. Rodgers, T. Wang, H. Berresheim, and K.L. Demerjian, Correlation of Ozone with NO_y in Photochemically Aged Air, J. Geophys. Res., 98, 2917-2926 (1993).

6. Parrish, D.D., M.P. Buhr, M. Trainer, R.B. Norton, J.P. Shimshock, F.C. Fehsenfeld, K.G. Anlauf, J.W. Bottenheim, Y.Z. Tang, H.A. Wiebe, J.M. Roberts, R.L. Tanner, L. Newman, V.C. Bowersox, K.J. Olszyna, E.M. Bailey, M.O. Rodgers, T. Wang, H. Berresheim, U.K. Roychowdhury, and K.L. Demerjian, The Total Reactive Oxidized Nitrogen Levels and the Partitioning Between the Individual Species at Six Rural Sites in Eastern North America, J. Geophys. Res., 98, 2927-2940 (1993).

7. Berresheim, H., D.J. Tanner, and F.L. Eisele, Real-Time Measurement of Dimethylsulfoxide in Ambient Air, Anal. Chem., 65, 84-86 (1993).

8. Lin, X., W.L. Chameides, C.S. Kiang, A.W. Stelson, and H. Berresheim, A model study of the formation of cloud condensation nuclei in remote marine areas, J. Geophys. Res., 97, 18161-18172 (1992).

G-35-620 #3

OMB Number 345-0058

NATIONAL SCIENCE FOUNDATION
4201 Wilson Blvd.,
Arlington, VA 22230

BULK RATE
POSTAGE & FEES PAID
National Science Foundation
Permit No. G-69

PI/PD Name and Address

Paul H. Wine
PSL-GTRI
GA Tech Res Corp - GTRI
Atlanta GA 30332

NATIONAL SCIENCE FOUNDATION
FINAL PROJECT REPORT

PART I - PROJECT IDENTIFICATION INFORMATION

1. Program Official/Org. Jarvis L. Moyers - ATM

2. Program Name ATMOSPHERIC CHEMISTRY PROGRAM

3. Award Dates (MM/YY) From: 10/91 To: 03/96

4. Institution and Address
GA Tech Res Corp - GIT
Administration Building
Atlanta GA 30332

5. Award Number 9113681

6. Project Title
A Comparative Study of the Atmospheric Sulfur Budget in Different Natural Environments

This Packet Contains
NSF Form 98A
And 1 Return Envelope

SF Grant Conditions (Article 17, GC-1, and Article 9, FDP-11) require submission of a Final Project eport (NSF Form 98A) to the NSF program officer no later than 90 days alter the expiration of the ward. Final Project Reports for expired awards must be received before new awards can be made SF Grants Policy Manual Section 677).

low, or on a separate page attached to this form, provide a summary of the completed projects and technical information. Be re to include your name and award number on each separate page. See below for more instructions.

PART II - SUMMARY OF COMPLETED PROJECT (for public use)

e summary (about 200 words) must be self-contained and intelligible to a scientifically literate reader. Without restating the oject title, it should begin with a topic sentence stating the project's major thesis. The summary should include, if pertinent the project being described, the following items:

The primary objectives and scope of the project
The techniques or approaches used only to the degree necessary for comprehension
The findings and implications stated as concisely and informatively as possible

SEE ATTACHMENT

PART III - TECHNICAL INFORMATION (for program management use)

st references to publications resulting from this award and briefly describe primary data, samples, physical collections, ventions, software, etc. created or gathered in the course of the research and, if appropriate, how they are being made available the research community. Provide the NSF Invention Disclosure number for any invention.

SEE ATTACHMENT

ertify to the best of my knowledge (1) the statements herein (excluding scientific hypotheses and scientific opinion) are true and complete, and) the text and graphics in this report as well as any accompanying publications or other documents, unless otherwise indicated, are the original ork of the signatories or of individuals working under their supervision. I understand that willfully making a false statement or concealing a aterial fact in this report or any other communication submitted to NSF is a criminal offense (U.S. Code, Title 18, Section 1001).

	4/9/96
Principal Investigator/Project Director Signature	**Date**

IMPORTANT:
MAILING INSTRUCTIONS
Return this *entire* packet plus all attachments in the envelope attached to the back of this form. Please copy the information from Part I, Block I to the *Attention block* on the envelope.

II. PROJECT SUMMARY

Three major objectives were pursued during this project. These objectives (A, B, and C) are identified and progress is summarized below.

A. Studies of the Link Between DMS Oxidation and CCN Formation

Data obtained during the April 1991 Pacific Stratus Investigation (PSI-3) provided a major improvement in our understanding of the atmospheric oxidation of dimethylsulfide (DMS) and its relation to the formation of cloud condensation nuclei (CCN). Major conclusions included the following: (1) the lifetimes of the major oxidation products dimethylsulfoxide (DMSO), sulfuric acid (H_2SO_4), and methanesulfonic acid (MSA) were estimated to be 1 - 3 hours under the measurement conditions encountered; (2) a clear correlation between CCN concentrations at 0.3% supersaturation and both H_2SO_4 and non-sea-salt sulfate aerosol in marine air was observed suggesting a link with DMS oxidation; (3) at higher supersaturation levels (0.9%) the above-mentioned correlation was not observed, thus indicating the importance of other aerosol types with respect to CCN activation under these conditions.

B. Method development for Measurement of DMS Oxidation Products

In collaboration with Dr. Fred Eisele of GTRI and NCAR, a previously developed mass spectrometric technique for measurement of atmospheric DMSO was extended to allow measurements of $DMSO_2$ as well. Hence, DMSO and $DMSO_2$ can now be measured quasi-simultaneously at pptv levels and with fast time resolution. As in the previously developed technique for DMSO analysis, gaseous ammonium ions are prepared and used for reaction with the target molecule. In contrast to DMSO, the ammonium ion does not transfer a proton to $DMSO_2$ but instead forms a NH_4^+ - $DMSO_2$ adduct which is measured as a signal at 112 amu; DMSO is measured via the DMSO - H^+ species at 79 amu.

C. Sources and Sinks of Atmospheric OCS and CS_2

We have discovered a new and potentially important anthropogenic source of carbonyl sulfide (OCS) and carbon disulfide (CS_2): tire wear, i.e., abrasion of particles from automobile tires on pavements and other surfaces. Vulcanized rubber contains disulfide polymer linkages which are continuously broken up, forming CS_2 as a major sulfur-containing gaseous product. The emission is a function of ambient pressure and ozone levels. This source may contribute as much as 10% to the atmospheric OCS budget (via CS_2 oxidation).

An extensive field experiment focusing on the biosphere-atmosphere exchange of OCS and CS_2 was conducted during the spring and summer of 1992 in a corn field in Southern Georgia. These measurements were jointly conducted with Drs. L. Harper and R. Sharpe of the USDA Southern Piedmont Conservation Research Center in Watkinsville, Georgia; these investigators continuously measured CO_2, water vapor, ammonia, and heat flux employing eddy correlation techniques. Based on measured vertical profiles, we have concluded that both sulfur gases were significantly emitted from the soil, with emission rates depending on temperature and soil moisture. However, profiles measured in and above the corn canopy frequently showed a net deposition of OCS to the corn which most strongly developed in the midday to late afternoon hours.

In collaboration with H. Bingemer of the University of Frankfurt and G. Gravenhorst of the University of Göttingen, vertical profiles of OCS and CS_2 were measured in a 40 meter tower in the Solling Forest (Germany) during the summer of 1993. The results showed a strong increase in OCS levels above the canopy. Unfortunately, it was found that this was caused in large part by emissions from a charcoal factory located about 20 km upwind from the measurement site; the amount of bias in the data set resulting from this undesirable extra source is still being evaluated.

III. PUBLICATIONS RESULTING FROM THIS PROJECT

1. Berresheim, H., P.H. Wine, and D.D. Davis, Sulfur in the Atmosphere, in: Composition, Chemistry, and Climate of the Atmosphere, Chapter 8, 251-307, H.B. Singh (ed.), Van Nostrand Reinhold Publishers, New York (1995).

2. Lin, X., W.L. Chameides, C.S. Kiang, A.W. Stelson, and H. Berresheim, Reply to D.A. Hegg: Comment on A Model Study of the Formation of Cloud Condensation Nuclei in Remote Marine Areas, J. Geophys. Res., 98, 10815-10817 (1993).

3. Berresheim, H., F.L. Eisele, and D. J. Tanner, A Method for Real-Time Detection of Dimethylsulfone in Ambient Air, Anal. Chem., 65, 3168-3170 (1993).

4. Berresheim, H., F.L. Eisele, D.J. Tanner, D.S. Covert, L. McInnes, and D.C. Ramsey-Bell, Atmospheric Sulfur Chemistry and Cloud Condensation Nuclei (CCN) Concentrations Over the Northeastern Pacific Coast, J. Geophys. Res., 98, 12701-12711 (1993).

5. Pos, W.H., and H. Berresheim, Automotive Tire Wear as a Source for Atmospheric OCS and CS_2, Geophys. Res. Lett., 20, 815-817 (1993).

6. Berresheim, H., Distribution of Atmospheric Sulfur Species Over Various Wetland Regions in the Southeastern United States, Atmos. Environ., 27, 211-221 (1993).

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8. Parrish, D.D., M.P. Buhr, M. Trainer, R.B. Norton, J.P. Shimshock, F.C. Fehsnefeld, K.G. Anlauf, J.W. Bottenheim, Y.Z. Tang, H.A. Wiebe, J.M. Roberts, R.L.Tanner, L. Newman, V.C. Bowersox, K.J. Olszyna, E.M. Bailey, M.O. Rodgers, T. Wang, H. Berresheim, U.K. Roychowdhury, and K.L. Demerjian, The Total Reactive Oxidized Nitrogen Levels and the Partitioning Between the Individual Species at Six Rural Sites in Eastern North America, J. Geophys. Res., 98, 2927-2940 (1993).

9. Berresheim, H., D.J. Tanner, and F.L. Eisele, Real-Time Measurement of Dimethyl-sulfoxide in Ambient Air, Anal. Chem., 65, 84-86 (1993).

10. Lin, X., W.L. Chameides, C.S. Kiang, A.W. Stelson, and H. Berresheim, A Model Study of the Formation of Cloud Condensation Nuclei in Remote Marine Areas, J. Geophys. Res., 97, 18161-18172 (1992).

11. Berresheim, H., and V. Vulcan, Vertical Profiles of DMS, COS, CS_2, SO_2, and Aerosol Sulfur Compounds in a Loblolly Pine Forrest, Atmos. Environ., 26A, 2031-2036 (1992).

PART IV -- FINAL PROJECT REPORT -- SUMMARY DATA ON PROJECT PERSONNEL

(To be submitted to cognizant Program Officer upon completion of project)

The data requested below are important for the development of a statistical profile on the personnel supported by Federal grants. The information on this part is solicited in resonse to Public Law 99-383 and 42 USC 1885C. All information provided will be treated as confidential and will be safeguarded in accordance with the provisions of the Privacy Act of 1974. You should submit a single copy of this part with each final project report. However, submission of the requested information is not mandatory and is not a precondition of future award(s). Check the "Decline to Provide Information" box below if you do not wish to provide the nformation.

Please enter the numbers of individuals supported under this grant.
Do not enter information for individuals working less than 40 hours in any calendar year.

	Senior Staff		Post-Doctorals		Graduate Students		Under-Graduates		Other Participants[1]	
	Male	Fem.	Male	Fem.	Male	Fem.	Male	Fem.	Male	Fem.
A. Total, U.S. Citizens	2	0	0	1	1	0	0	0	0	0
B. Total, Permanent Residents	1	0	0	0	0	0	0	0	0	0
U.S. Citizens or Permanent Residents[2]:										
American Indian or Alaskan Native										
Asian				1						
Black, Not of Hispanic Origin										
Hispanic										
Pacific Islander										
White, Not of Hispanic Origin	3				1					
C. Total, Other Non-U.S. Citizens	0	0	0	0	1	1	0	0	0	1
Specify Country 1. Brazil					1					
2. Romania						1				
3. China										1
D. Total, All participants (A + B + C)	3	0	0	1	2	1	0	0	0	1
Disabled[3]	0	0	0	0	0	0	0	0	0	0

☐ Decline to Provide Information: Check box if you do not wish to provide this information (you are still required to return this page along with Parts I-III).

[1] Category includes, for example, college and precollege teachers, conference and workshop participants.

[2] Use the category that best describes the ethnic/racial status fo all U.S. Citizens and Non-citizens with Permanent Residency. *(If more than one category applies, use the one category that most closely reflects the person's recognition in the community.)*

[3] A person having a physical or mental impairment that substantially limits one or more major life activities; who has a record of such impairment; or who is regarded as having such impairment. *(Disabled individuals also should be counted under the appropriate ethnic/racial group unless they are classified as "Other Non-U.S. Citizens.")*

AMERICAN INDIAN OR ALASKAN NATIVE: A person having origins in any of the original peoples of North America and who maintains cultural identification through tribal affiliation or community recognition.

ASIAN: A person having origins in any of the original peoples of East Asia, Southeast Asia or the Indian subcontinent. This area includes, for example, China, India, Indonesia, Japan, Korea and Vietnam.

BLACK, NOT OF HISPANIC ORIGIN: A person having origins in any of the black racial groups of Africa.

HISPANIC: A person of Mexican, Puerto Rican, Cuban, Central or South American or other Spanish culture or origin, regardless of race.

PACIFIC ISLANDER: A person having origins in any of the original peoples of Hawaii; the U.S. Pacific territories of Guam, American Samoa, and the Northern Marinas; the U.S. Trust Territory of Palau; the islands of Micronesia and Melanesia; or the Philippines.

WHITE, NOT OF HISPANIC ORIGIN: A person having origins in any of the original peoples of Europe, North Africa, or the Middle East.